High-dimensional gene expression data often comprises a vast number of redundant genes, which poses challenges for machine learning algorithms due to its high dimensionality. Feature selection has emerged as an effective approach to enhance the performance of classification algorithms by addressing two primary objectives: reducing the number of features and improving classification accuracy. In this research, we introduce a novel hybrid multi-objective wrapper method for feature selection. Our proposed model combines the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and a multi-attribute decision-making approach, as a filtering mechanism for extracting informative features. Additionally, we employ a multi-objective Crow Search Algorithm (CSA) that concurrently minimizes the number of features and classification error, while obtaining a set of Pareto non-dominated (ND) solutions. To mitigate the risk of CSA converging towards local optima, we integrate an Opposition-Based Learning (OBL) technique, which serves as a local search mechanism. To evaluate the effectiveness of our model, we conduct experiments on benchmark micro-array datasets from the ADNI database. Comparative analysis is performed against six traditional single-objective methods and three other existing multi-objective methods. The results demonstrate that the proposed model outperforms the single-objective methods in terms of classification accuracy. The proposed model attained an average accuracy of 97.08% and selected 19 features, thereby outperforming other algorithms in both classification accuracy and the number of features selected.